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## INTRODUCTION

This chapter describes the basic functions and features of the HP 4142B. Included are discussions on output and measurement functions of each source and monitor unit, measurement modes, and a front/rear panel overview.

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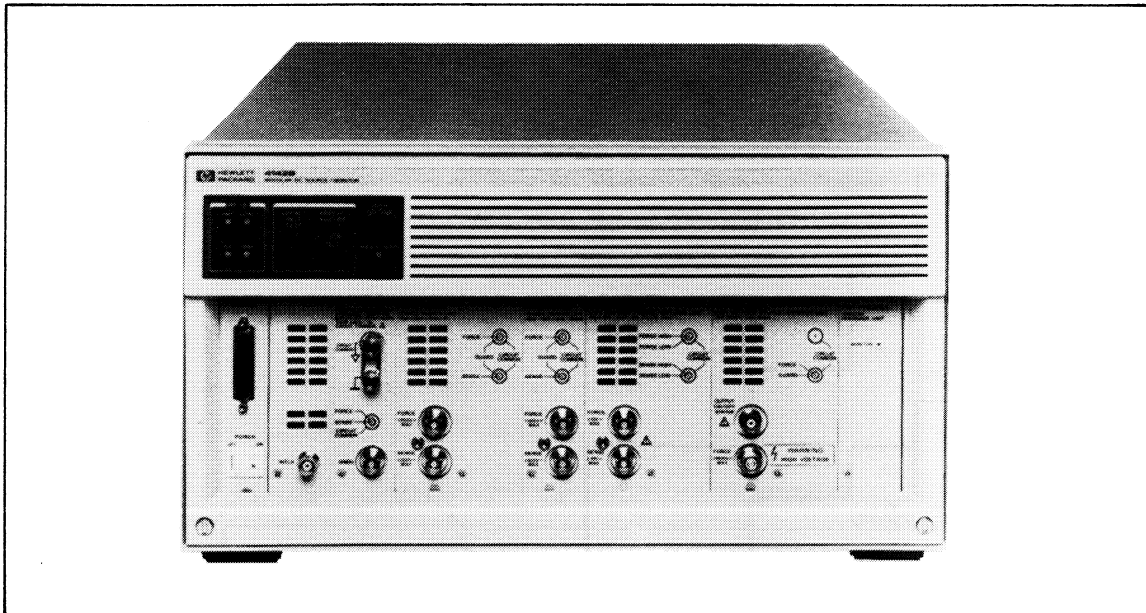
## PRODUCT INTRODUCTION

### HP 4142B

The HP 4142B is a high performance DC parametric measurement instrument with plug-in unit architecture designed for:

- Wide Measurement Range (10 A, 1000 V)
- High Resolution (20 fA, 4  $\mu$ V)
- High Speed (Force I or V: 4 ms, Measure I or V: 4 ms)
- High Accuracy (V: 0.05%, I: 0.2%)

All HP 4142B operations--measurement set up and execution, and measurement data receipt--are computer-controlled via the Hewlett-Packard Interface Bus (HP-IB). Up to 1023 measurement data (4095 for binary data format) can be stored in internal memory.

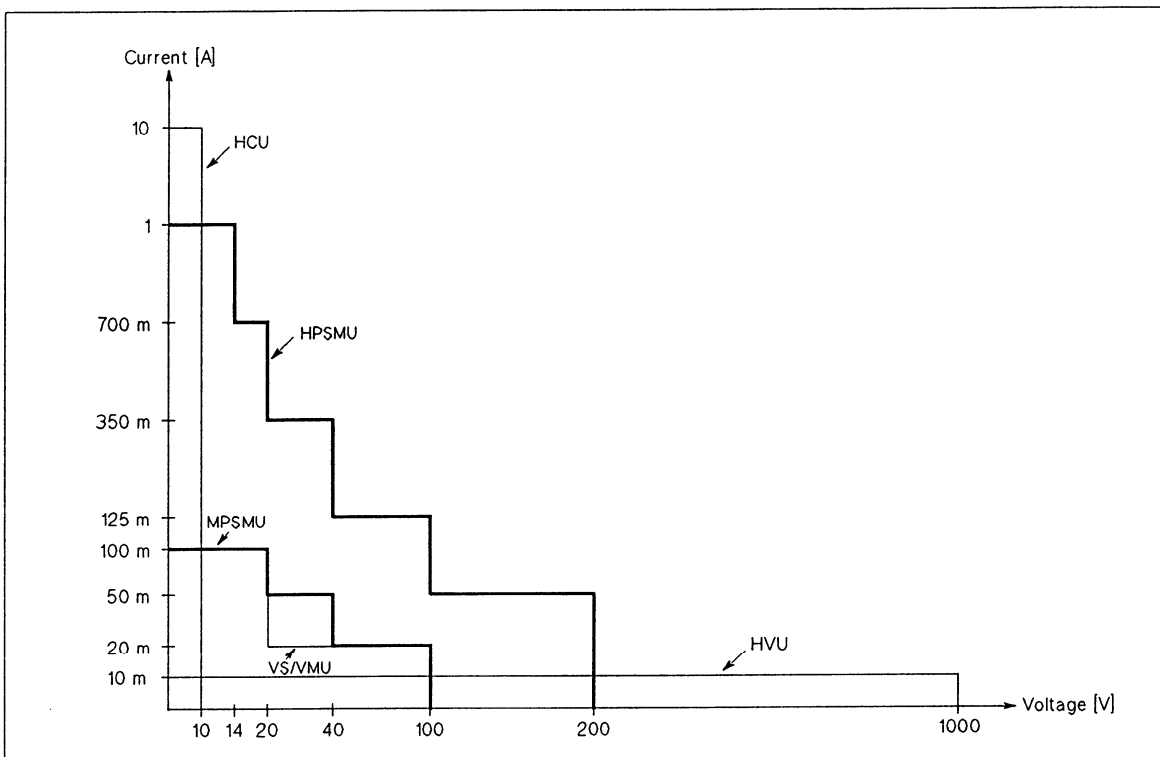


HP 4142B Modular DC Source/Monitor

As a measurement unit, the following five types of plug-in units are available, in addition to a built-in, 0 V source Ground Unit (GNDU). The plug-in units can be built-in to up to eight slots.

- HP 41420A Source/Monitor Unit, 40 $\mu$ V-200V/20fA-1A (High Power SMU, HPSMU). Occupies 2 slots.
- HP 41421B Source/Monitor Unit, 40 $\mu$ V-100V/20fA-100mA (Medium Power SMU, MPSMU). Occupies 1 slot.
- HP 41422A High Current Source/Monitor Unit, 40 $\mu$ V-10V/20nA-10A (HCU). Occupies 2 slots.
- HP 41423A High Voltage Source/Monitor Unit, 2mV-1000V/2pA-10mA (HVU). Occupies 2 slots.
- HP 41424A Voltage Source/ Voltage Monitor Unit (VS/VMU). Occupies 1 slot.
- HP 41425A Analog Feedback Unit (AFU). Occupies 1 slot. No more than one HP 41425A per mainframe.

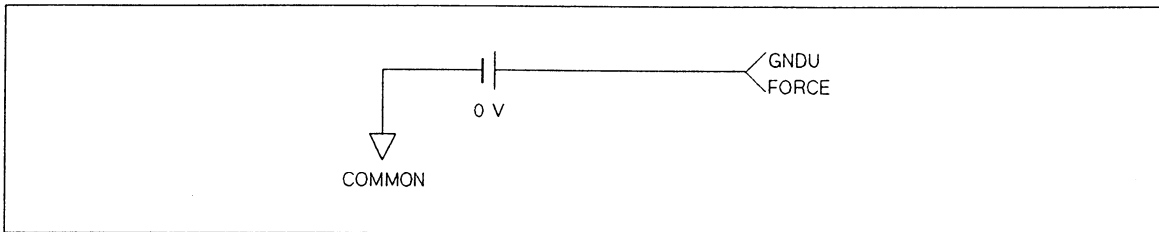
The following figure shows the output and measurement range of plug-in units.



**Output and Measurement Range of Plug-in Units**

## Ground Unit (GNDU)

The Ground Unit (GNDU) is a 0 V constant source that provides a measurement ground reference, and can sink up to  $\pm 1.6$  A. The following figure shows a simplified GNDU circuit diagram.



**Simplified GNDU Circuit Diagram**

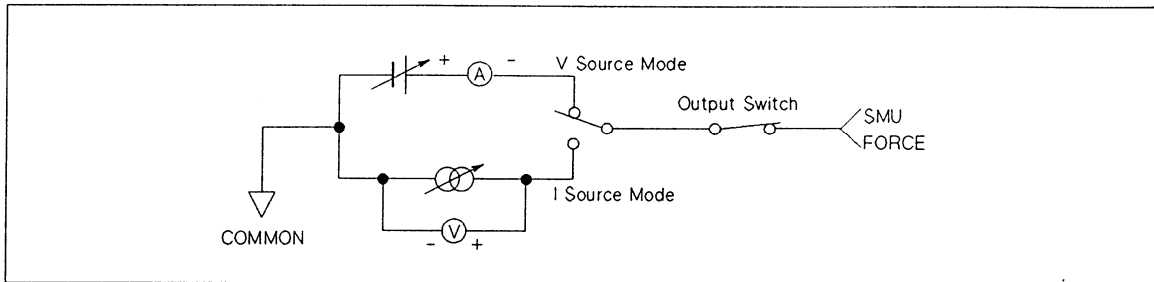
## HP 41420A HPSMU and HP 41421B MPSMU

The HP 41420A Source/Monitor Unit (High Power SMU: HPSMU) can force and measure up to  $\pm 200$  V or  $\pm 1$  A (maximum power: 14 W).

The HP 41421B Source/Monitor Unit (Medium Power SMU: MPSMU) can force and measure up to  $\pm 100$  V or  $\pm 100$  mA (maximum power: 2 W).

Each SMU functions in either of the following two modes:

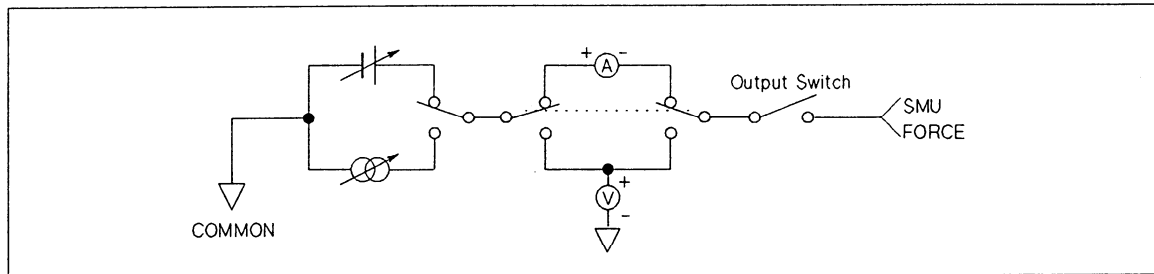
- V source (constant or pulse) and I monitor
- I source (constant or pulse) and V monitor



**Simplified SMU Circuit Diagram**

In High speed spot measurements, Analog search measurements, and Quasi-pulsed spot measurements (described later), the SMU functions in the following two modes in addition to the above two modes:

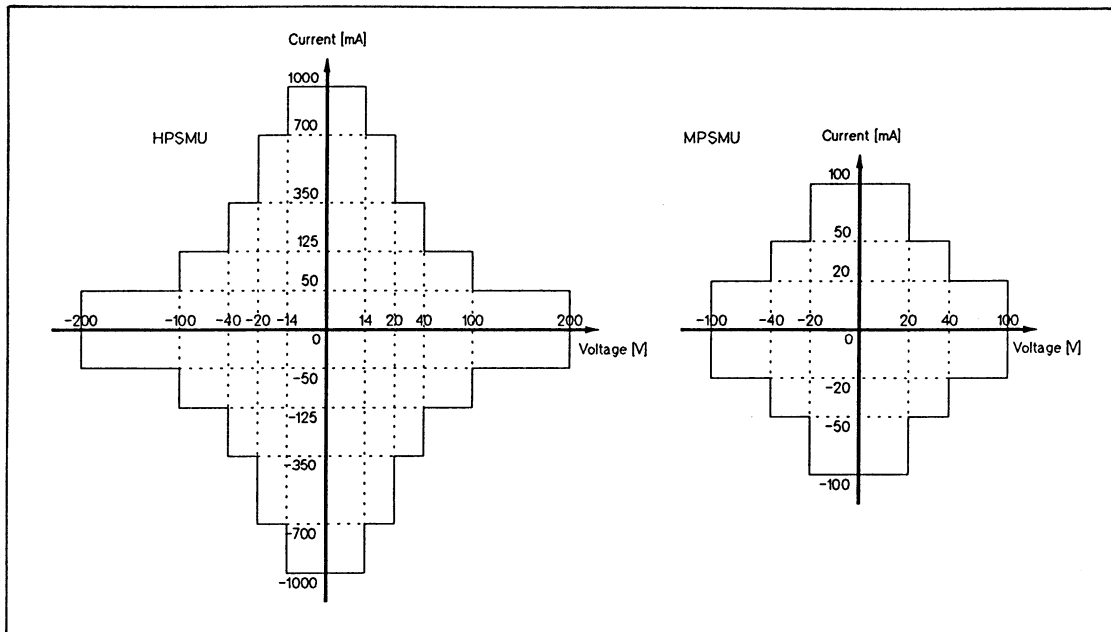
- V source (constant only) and V monitor
- I source (constant only) and I monitor



**SMU Circuit Diagram**

The following figure and table list HPSMU/MPSMU output and measurement ranges.

## HPSMU/MPSMU Output and Measurement Ranges



Range	Output/Measurement Value	Resolution <sup>1</sup> Output/Meas.	Maximum Output	
			HPSMU	MPSMU
2 V	$0 \leq  V  \leq 2 V$	100 $\mu$ V/40 $\mu$ V	$\pm 1 A$	$\pm 100 mA$
20 V	$0 \leq  V  \leq 14 V$	1mV/400 $\mu$ V	$\pm 1 A$	$\pm 100 mA$
	$14 V <  V  \leq 20 V$	1mV/400 $\mu$ V	$\pm 700 mA$	$\pm 100 mA$
40 V	$0 \leq  V  \leq 40 V$	2mV/800 $\mu$ V	$\pm 350 mA$	$\pm 50 mA$
100 V	$0 \leq  V  \leq 100 V$	5mV/2mV	$\pm 125 mA$	$\pm 20 mA$
200 V	$0 \leq  V  \leq 200 V$	10mV/4mV	$\pm 50 mA$	---
1 nA <sup>2</sup>	$0 \leq  I  \leq 1.15 nA$	50fA/20fA	$\pm 200 V$	$\pm 100 V$
10 nA <sup>3</sup>	$0 \leq  I  \leq 11.5 nA$	500fA/200fA	$\pm 200 V$ <sup>4</sup>	$\pm 100 V$ <sup>4</sup>
100 nA <sup>3</sup>	$0 \leq  I  \leq 115 nA$	5pA/2pA	$\pm 200 V$ <sup>4</sup>	$\pm 100 V$ <sup>4</sup>
1 $\mu$ A <sup>3</sup>	$0 \leq  I  \leq 1.15 \mu A$	50pA/20pA	$\pm 200 V$ <sup>4</sup>	$\pm 100 V$ <sup>4</sup>
10 $\mu$ A <sup>3</sup>	$0 \leq  I  \leq 11.5 \mu A$	500pA/200pA	$\pm 200 V$ <sup>4</sup>	$\pm 100 V$ <sup>4</sup>
100 $\mu$ A	$0 \leq  I  \leq 115 \mu A$	5nA/2nA	$\pm 200 V$	$\pm 100 V$
1 mA	$0 \leq  I  \leq 1.15 mA$	50nA/20nA	$\pm 200 V$	$\pm 100 V$
10 mA	$0 \leq  I  \leq 11.5 mA$	500nA/200nA	$\pm 200 V$	$\pm 100 V$
100 mA	$0 \leq  I  \leq 20 mA$	5 $\mu$ A/2 $\mu$ A	$\pm 200 V$	$\pm 100 V$
	$20 mA <  I  \leq 50 mA$	5 $\mu$ A/2 $\mu$ A	$\pm 200 V$	$\pm 40 V$
	$50 mA <  I  \leq 115 mA$ <sup>5</sup>	5 $\mu$ A/2 $\mu$ A	$\pm 100 V$	$\pm 20 V$
1 A	$0 \leq  I  \leq 50 mA$	50 $\mu$ A/20 $\mu$ A	$\pm 200 V$	---
	$50 mA <  I  \leq 125 mA$	50 $\mu$ A/20 $\mu$ A	$\pm 100 V$	---
	$125 mA <  I  \leq 350 mA$	50 $\mu$ A/20 $\mu$ A	$\pm 40 V$	---
	$350 mA <  I  \leq 700 mA$	50 $\mu$ A/20 $\mu$ A	$\pm 20 V$	---
	$700 mA <  I  \leq 1 A$	50 $\mu$ A/20 $\mu$ A	$\pm 14 V$	---

<sup>1</sup> V/I Output Resolution: 1/20000, V/I Measurement Resolution: 1/50000

<sup>2</sup> The 1 nA range cannot force and measure pulse current.

<sup>3</sup> When the pulse voltage output is in the 20 V through 200 V range, 10 nA through 10  $\mu$ A measurement ranges cannot be used.

<sup>4</sup> When the pulse current output is in the 100 nA through 10  $\mu$ A range, the maximum voltage is 2 V.

<sup>5</sup> For MPSMU, 100 mA

Pulse parameters are:

Pulse width: 1 ms to 50 ms, 100  $\mu$ s resolution

Pulse period: 10 ms to 500 ms, 100  $\mu$ s resolution

Maximum pulse duty (pulse width/ pulse period): 50%

Output and measurement ranges:

2 V output range: 10 nA to 1 A measurement range

20 V to 200 V output range: 100  $\mu$ A to 1 A measurement range

10 nA to 10  $\mu$ A output range: 2 V measurement range

100  $\mu$ A to 1 A output range: 2 V to 200 V measurement range

For current pulse, the pulse base current and pulse current must have the same polarity.

Each SMU includes a compliance feature that limits output voltage or current to prevent damage to your device. When the SMU forces voltage, you can specify I compliance. When the SMU forces current, you can specify V compliance. You can specify V or I compliance with the same resolution as the output voltage or current within the maximum output.

## HP 41422A HCU

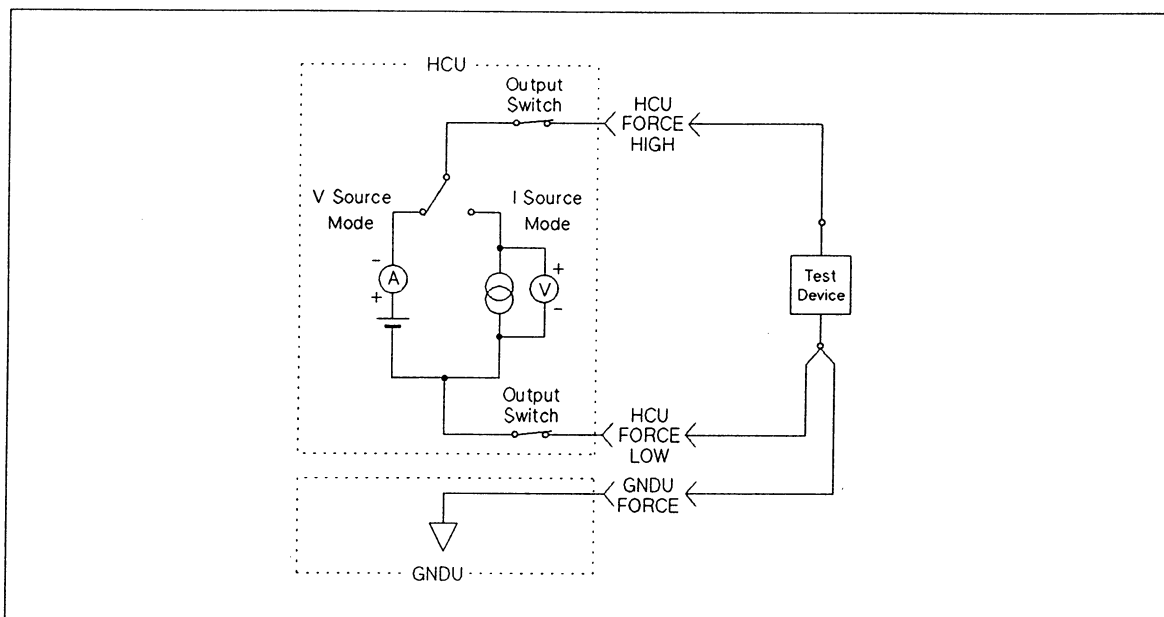
HP 41422A High Current Source/Monitor Unit (HCU) can force and measure up to 10 A and 10 V, and functions in either of the following two modes:

- Pulsed V source and I monitor
- Pulsed I source and V monitor

The HCU can force pulsed voltage or pulsed current, but cannot force constant voltage or constant current. When the HCU does not force a pulse value, the HCU functions as 0 V source. (Maximum current: 0.1% of the current range value. 10 mA maximum at the 10 A range.)

The following figure shows a simplified HCU circuit diagram. Although the HCU is a floating source/monitor, the LOW line of the HCU must be connected to the GNDU and fixed to 0 V. Therefore, HCU circuit (including GNDU) is equivalent to the SMU circuit.

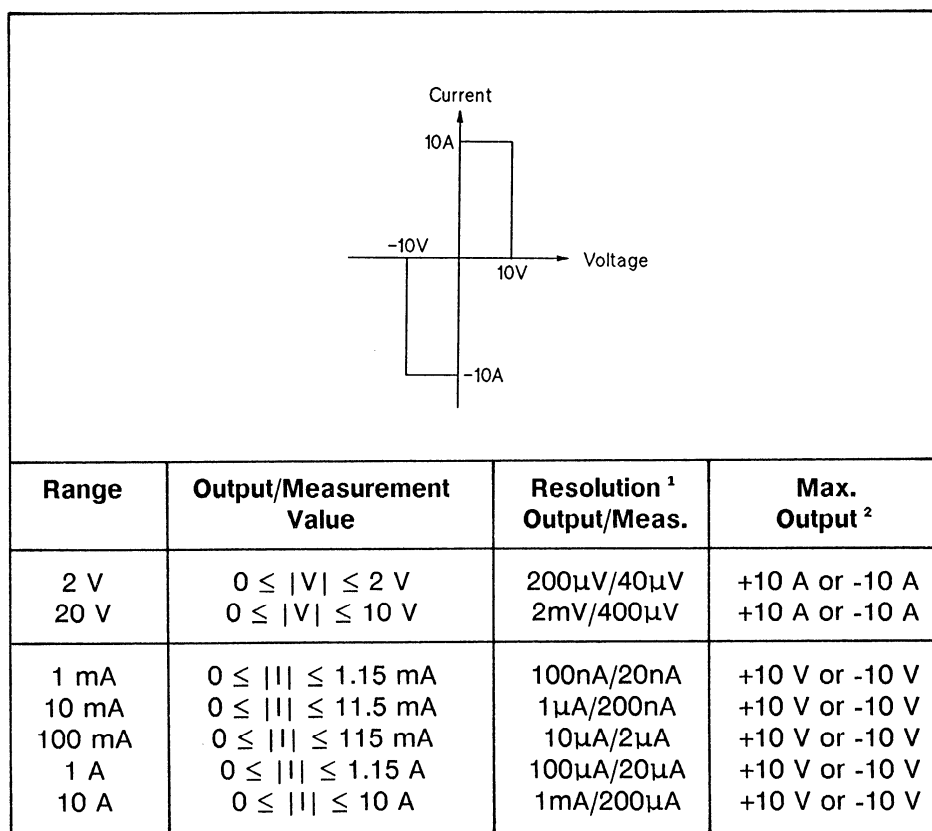
You cannot connect an SMU, HVU, or VS in place of the GNDU.



**Simplified HCU Circuit Diagram**

The following table shows the HCU output and measurement ranges. The HCU is a unipolar source, that is, voltage and current output are limited to the same polarity.

**HCU Output/Measurement Ranges**



<sup>1</sup> V/I Output Resolution: 1/10000, V/I Measurement Resolution: 1/50000

<sup>2</sup> The polarity of maximum output is positive if the output value is positive, and negative if the output value is negative.

Pulse parameters are:

Pulse width: 100  $\mu$ s to 1 ms, 100  $\mu$ s resolution

Pulse period: 10 ms to 500 ms, 100  $\mu$ s resolution

Maximum pulse duty (pulse width/ pulse period):

10% (if output current or I compliance is 1 A or less.)

1% (if output current or I compliance is more than 1 A.)

The pulse base output is always 0 V for voltage pulse and current pulse.

An HCU includes a compliance feature that limits output voltage or current to prevent damage to your device (same as the HPSMU/MPSMUs).



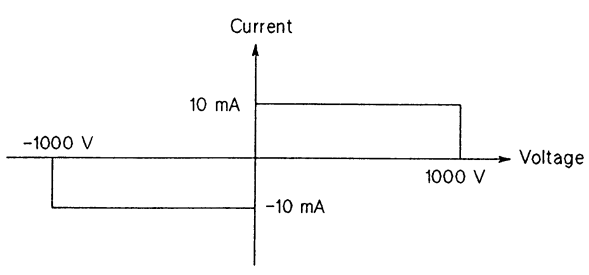
## HP 41423A HVU

The HP 41423A High Voltage Source/Monitor Unit (HVU) can force and measure up to  $\pm 1000$  V or  $\pm 10$  mA (maximum power: 10 W).

The HVU circuit diagram is the same as the HPSMU/MPSMU. However, the HVU cannot perform analog search measurements.

The following table shows the HVU output and measurement ranges. The HVU is a unipolar source, that is, voltage and current output are limited to the same polarity.

**HVU Output/Measurement Ranges**



Range	Output/Measurement Value	Resolution <sup>1</sup> Output/Meas.	Max. Output <sup>2</sup>
100 V	$0 \leq  V  \leq 100$ V	10mV/2mV	+10 mA or -10 mA
200 V	$0 \leq  V  \leq 200$ V	20mV/4mV	+10 mA or -10 mA
500 V	$0 \leq  V  \leq 500$ V	50mV/10mV	+10 mA or -10 mA
1000 V	$0 \leq  V  \leq 1000$ V	100mV/20mV	+10 mA or -10 mA
100 nA	$0 \leq  I  \leq 115$ nA	50pA/2pA	+1000 V or -1000 V
1 $\mu$ A	$0 \leq  I  \leq 1.15$ $\mu$ A	500pA/20pA	+1000 V or -1000 V
10 $\mu$ A	$0 \leq  I  \leq 11.5$ $\mu$ A	5nA/200pA	+1000 V or -1000 V
100 $\mu$ A	$0 \leq  I  \leq 115$ $\mu$ A	50nA/2nA	+1000 V or -1000 V
1 mA	$0 \leq  I  \leq 1.15$ mA	500nA/20nA	+1000 V or -1000 V
10 mA	$0 \leq  I  \leq 10$ mA	5 $\mu$ A/200nA	+1000 V or -1000 V

<sup>1</sup> V Output Resolution: 1/10000, I Output Resolution: 1/2000,  
V/I Measurement Resolution: 1/50000

<sup>2</sup> The polarity of maximum output is positive if the output value is positive, and negative if the output value is negative.

Pulse parameters are:

Pulse width: 1 ms to 50 ms, 100  $\mu$ s resolution

Pulse period: 10 ms to 500 ms, 100  $\mu$ s resolution

Maximum pulse duty (pulse width/ pulse period): 50%

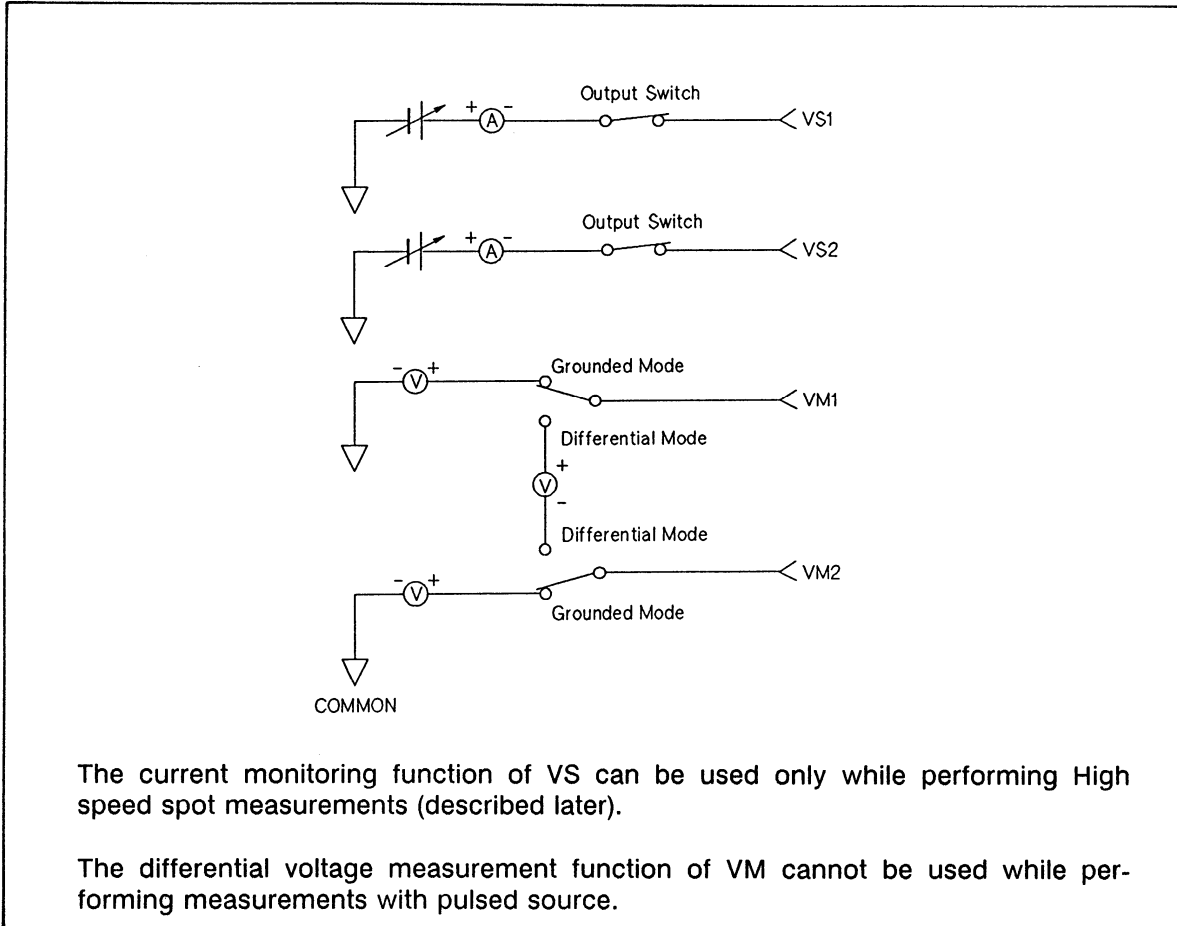
The pulse base value and pulse value of the HVU must have the same polarity, and the maximum voltage difference of the pulse base voltage and pulse voltage is 600 V, which is the maximum voltage difference that can be settled with a maximum pulse width of 50 ms.

An HVU includes a compliance feature that limits output voltage or current to prevent damage to your device (same as the HPSMU/MPSMUs).

## HP 41424A VS/VMU

The HP 41424A V Source/V Monitor Unit (VS/VMU) provides:

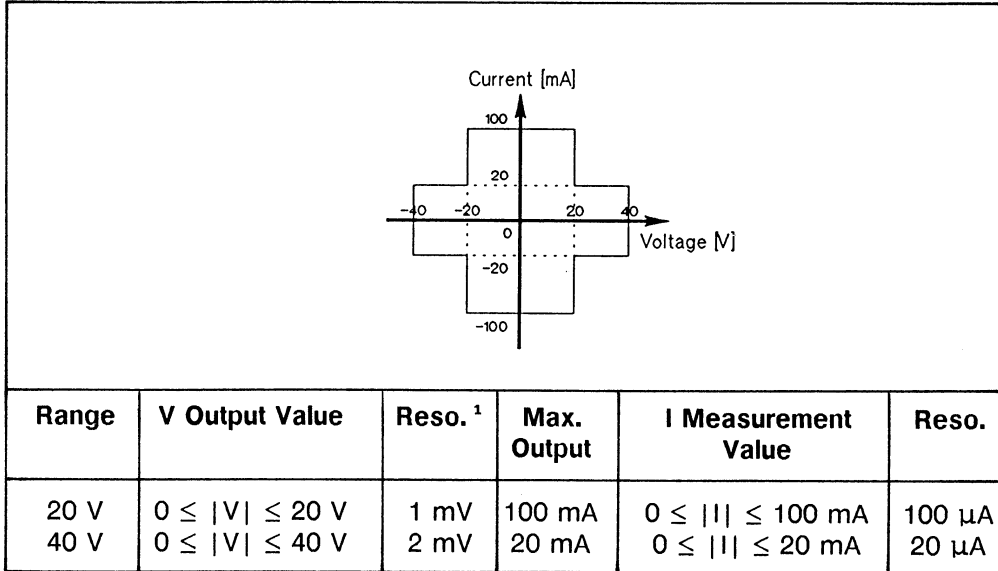
- V source (constant or pulse) and I monitor (VS), 2ch
- V monitor (VM), 2ch for grounded measurement, or 1ch for differential measurement



**Simplified VS/VMU Circuit Diagram**

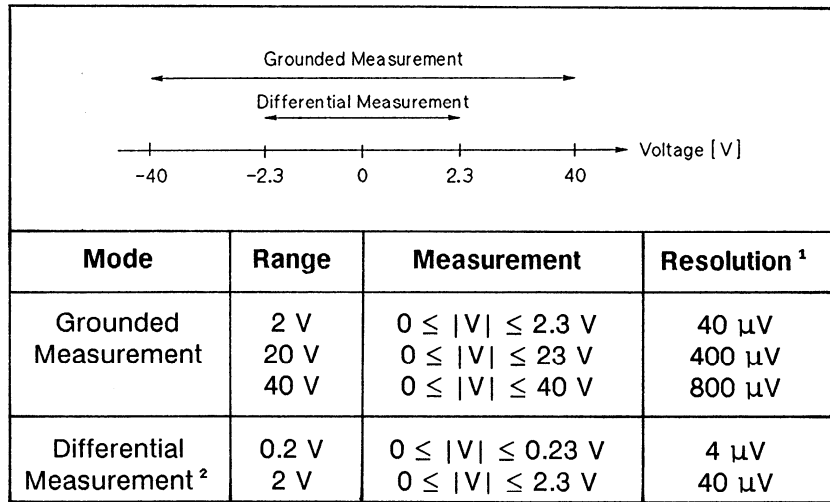
VS can force up to 40 V, and VM can measure up to 40 V. The following tables show the V output range and I measurement range of VS, and the V measurement range of VM.

### VS Output and Measurement Ranges



<sup>1</sup> V Output Resolution: 1/20000, I Measurement Resolution: 1/1000

### VM Measurement Ranges



<sup>1</sup> V Measurement Resolution: 1/50000

<sup>2</sup> Each voltage of differential input must be within  $\pm 40 \text{ V}$ .

Pulse parameters are the same as the SMU:

Pulse width: 1 ms to 50 ms, 100  $\mu\text{s}$  resolution

Pulse period: 10 ms to 500 ms, 100  $\mu\text{s}$  resolution

Maximum pulse duty (Pulse width/ Pulse period): 50%

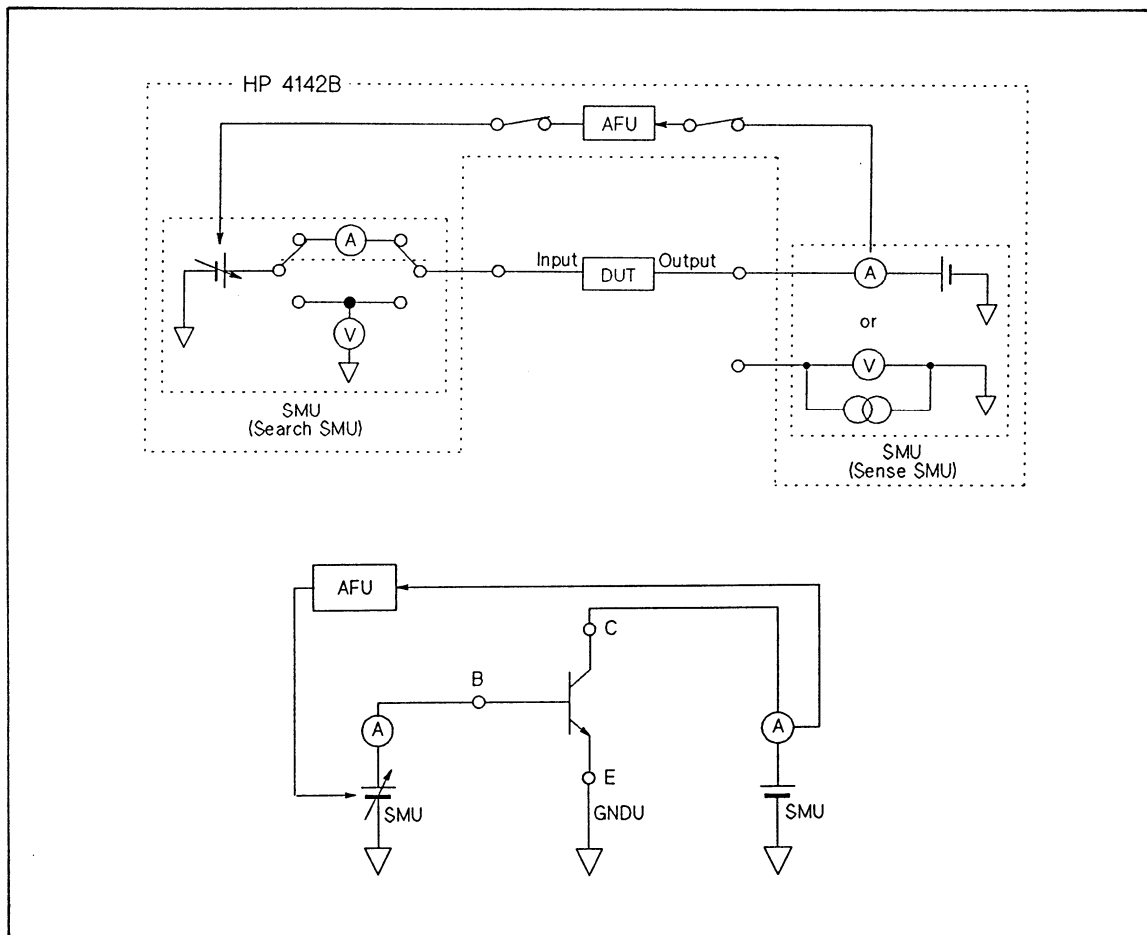
The VS has a current limiter. The limiter value is automatically determined by the output voltage range. If the output range is 20 V, then the current limit is 100 mA. If the output range is 40 V, then the current limit is 20 mA.

## HP 41425A AFU

The HP 41425A Analog Feedback Unit (AFU) controls the output voltage of one SMU (HPSMU or MPSMU, called the search SMU), and set the monitor value of another SMU (HPSMU or MPSMU, called the sense SMU) to the specified value. The monitor value is current if the sense SMU is set to V source, and it is voltage if the sense SMU is set to I source. The SMUs specified for use are automatically connected internally to the AFU. The following figure shows a simplified AFU operational diagram.

The major applications of the AFU are:

- Bipolar transistor hFE measurement at the specified collector voltage and collector current.
- MOSFET Vth measurement at the specified drain voltage and drain current.



**Simplified AFU Operational Diagram**

## Measurement Modes

By using the measurement units, you can perform the following ten types of measurements. The output waveform and available units are shown for each measurement mode in the following figure. The explanation number below corresponds to the No. in the figure.

- 1) Spot measurements  
Up to 16 sources force constant voltages and currents, and up to 8 monitors measure the outputs.
- 2) Staircase sweep measurements  
One source sweeps constant V or I, while up to 8 monitors measure the outputs.  
Or two sources sweep constant voltages or currents at the same time, while up to 8 monitors measure the outputs.
- 3) 1ch pulsed spot measurements  
One source forces pulsed V or I, and one monitor measures the output.
- 4) Pulsed sweep measurements  
One source sweeps pulsed V or I, while one monitor measures the output.
- 5) Staircase sweep with pulsed bias measurements  
One source sweeps constant V or I, and another source forces pulsed V or I with synchronized sweep output, while one monitor measures the output.
- 6) Analog search measurement  
Searches for a specified current or voltage on one SMU by controlling the voltage output of another SMU.  
The AFU is required.
- 7) 2ch pulsed spot measurements  
Two sources force pulsed outputs at the same time, and one monitor measures the output.  
At least one pulsed source must be an HCU.
- 8) Pulsed sweep with pulsed bias measurement  
One source sweeps pulsed V or I, and another source forces pulsed V or I with synchronized sweep pulsed output, while one monitor measures the output.  
At least one pulsed source must be an HCU.
- 9) Quasi-pulsed spot measurement  
One source and monitor unit forces voltage and detects when the voltage is settled, then the same or another monitor measures the output. Immediately after the measurement, the source and monitor unit returns to the original voltage.
- 10) High speed spot measurement  
Up to 16 sources force constant voltages and currents, and one monitor measures the outputs. You can perform the measurement with fewer commands than spot measurement.

### Available Units in Each Measurement Mode

No.	Output Waveform	Source				Monitor						AFU
		SMU (V/I)	HCU (V/I)	HVU (V/I)	VS (V)	SMU (V/I)	HCU (V/I)	HVU (V/I)	VS (I)	VM		
										(V <sup>1</sup> )	(VD <sup>2</sup> )	
1		●		●	●	●		●		●	●	
2		●		●	●	●		●		●	●	
		●		●	●	●		●		●	●	
3		●	●	●	●	●	●	●		●		
4		●	●	●	●	●	●	●		●		
5		●		●	●	●	●	●		●		
		●	●	●	●	●	●	●		●		
6		●				●						●
		●				●						
7		● <sup>3</sup>	●			●	●	●		●		
		● <sup>3</sup>	●			●	●	●		●		
8		● <sup>3</sup>	●			●	●	●		●		
		● <sup>3</sup>	●			●	●	●		●		
9		●		●		●		●				
10		●		●	●	●		●	●	●	●	

<sup>1</sup> Grounded measurement mode

<sup>2</sup> Differential measurement mode

<sup>3</sup> At least one pulsed source must be an HCU.

## Total Power Limitation of Plug-in Units

Total SMU, HCU, HVU, and VS power consumption must not exceed 32 W. If you do not have an HPSMU, an HCU, an HVU, or more than six VS/VMUs, total power consumption can not reach 32 W. Your HP 4142B is not limited by the total power of the units. Power consumption depends on the output settings for voltage and current, and is calculated as follows. Note that when the output switch of the unit is set to OFF, the power of that unit is 0 W.

Unit	Power <sup>1</sup>
SMU	2 V, 20 V range <sup>2</sup> : 20(Iset <sup>3</sup> ) [W] 40 V range: 40(Iset) [W] 100 V range: 100(Iset) [W] 200 V range: 200(Iset) [W]
HCU	20(Iset)(pulse duty <sup>4</sup> )+10 [W]
HVU	(Vset <sup>5</sup> )(Iset)+10 [W]
VS	20 V range: 2.2 [W] 40 V range: 0.88 [W]

<sup>1</sup> Output switch set to OFF: 0 W

The power of each unit is rounded down to the nearest hundredth. For example, if the calculation result is 1.057 W, then power = 1.05 W. If 0.002 W, then power = 0 W.

<sup>2</sup> If the SMU is the I source mode, voltage range is the lowest range that includes the voltage compliance value. For example, if you set the voltage compliance to 5 V, voltage range is 20 V.

<sup>3</sup> Iset is the specified output current value at I source mode, and is the specified current compliance value at V source mode.

<sup>4</sup> The pulse duty is defined: (pulse duty) = (pulse width/ pulse period).

<sup>5</sup> Vset is the specified output voltage value at V source mode, and is the specified voltage compliance value at I source mode.

Maximum value of power consumption for these units is as follows.

HPSMU: 20 W

MPSMU: 2 W

HCU: 12 W

HVU: 20 W

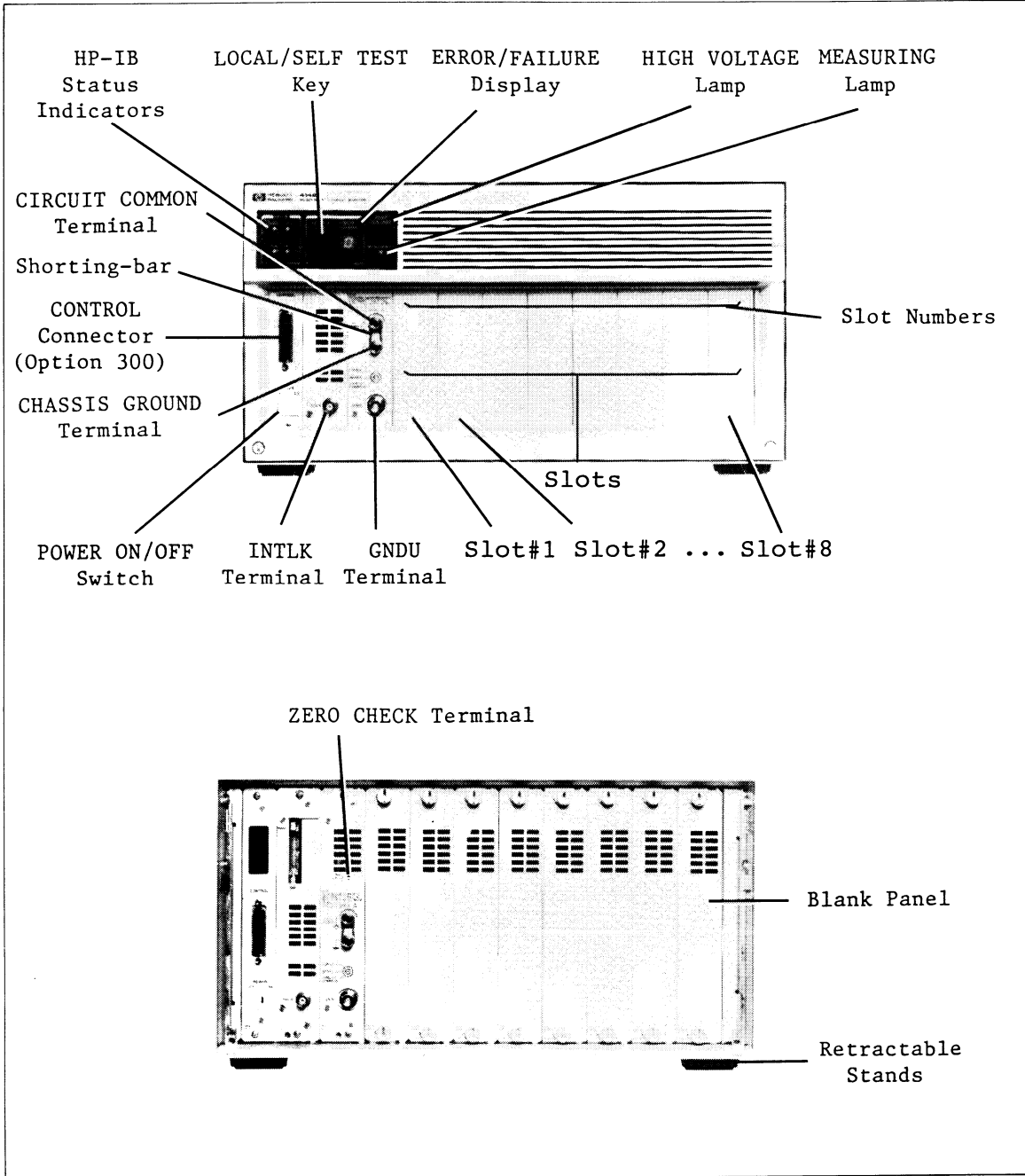
VS/VMU: 4.4 W

For example, if you have two HPSMUs, total maximum power consumption is 40 W (20 W + 20 W) and exceeds 32 W. You cannot force the maximum output of each unit at the same time. The maximum current of the two units is limited to 1.6 A (32W/20V).

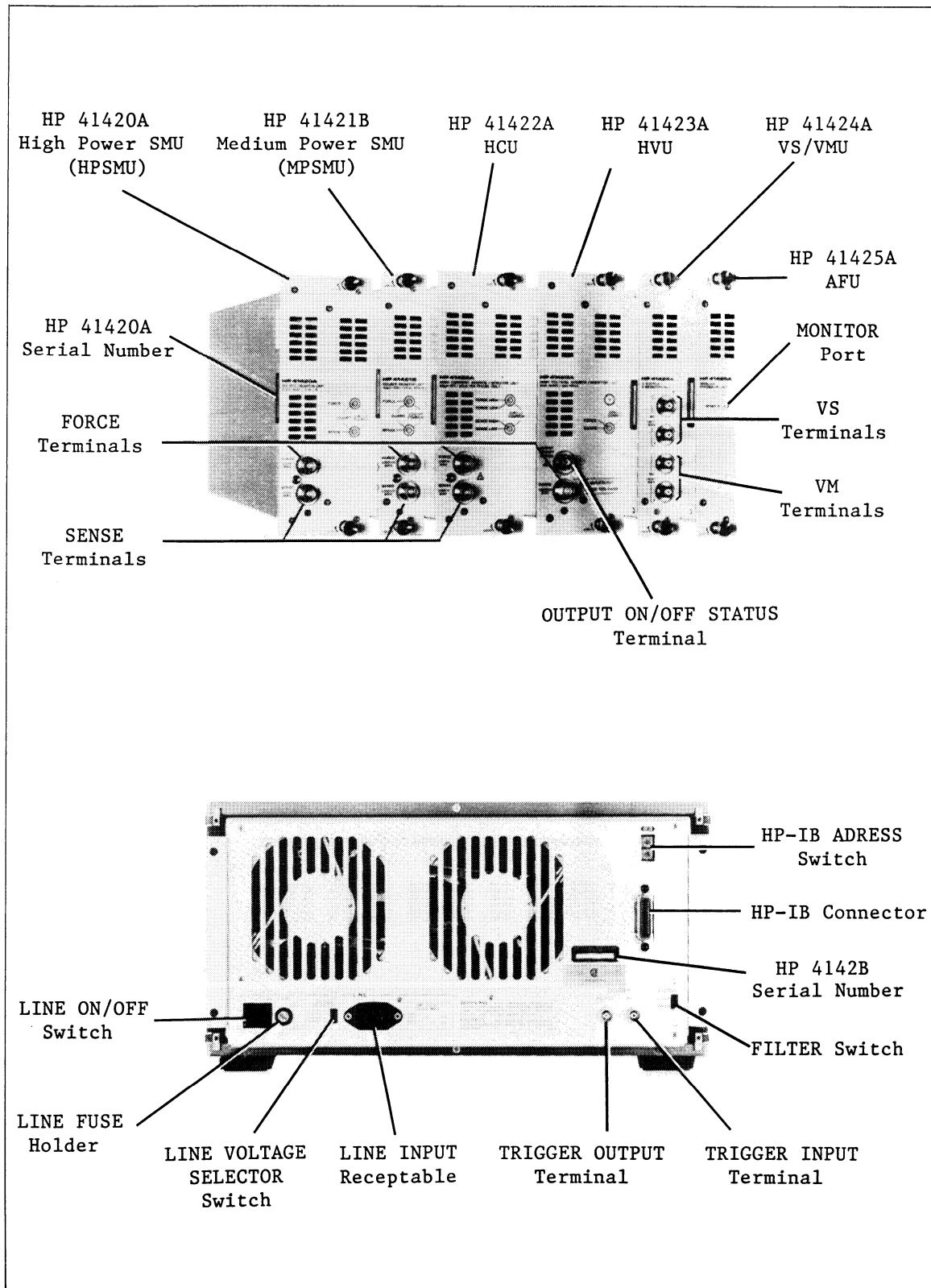


## PANEL OVERVIEW

The following figures point out important locations on the HP 4142B. The name of each part is referenced in this manual.



HP 4142B Panel Overview (1 of 2)



HP 4142B Panel Overview (2 of 2)